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Observations on the food and feeding habits of some African robins (Aves: Turdinae)

by

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SYNOPSIS

Details are given of the feeding habits and dietary preferences of 22 species of birds of the genera *Erythropygia*, *Sheppardia*, *Stiphrornis*, *Pogonocichla*, *Swynnertonia* and *Cossypha* of the sub-family *Turdinae* (Thrushes), resident in sub-saharan Africa.

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INTRODUCTION

The importance of food availability to tropical bird communities has been much discussed in recent years and considerable speculation has arisen due to a basic lack of data. Whilst it is known in very broad terms what most African birds eat, the finer details of dietary preferences are known for only very few species, and these mostly of birds which are of economic importance.

The present study is concerned with a relatively little known group of birds comprising several genera in the subfamily Turdinae. Turdid genera are numerous and not easy to divide into discrete groups, so the selection studied here is rather arbitrary. In fact the original criteria for species inclusion in the pilot study was that the bird had to be a 'robin'; inevitably, as data collection proceeded (the study of food and feeding habits forming only one aspect of a much broader project) some extra genera that were obviously closely related had to be included in the field studies. The present tally of species totals 32 in sub-saharan Africa, and varying amounts of data have been collected for 22 of these.

Most African robins are inhabitants of evergreen forests or woodlands and a few are dwellers in semi-desert. Six genera (three of which are monotypic) are involved, namely *Erythropygia*, *Sheppardia*, *Stiphrornis*, *Pogonocichla*, *Swynnertonia* and *Cossypha*. Despite this apparent heterogeneity, it is evident that these robins are sufficiently closely related to one another to share several characteristics and for the purpose of the present survey they may be considered to form a relatively homogeneous assemblage of species. In assessing the often rather meagre data presented here it will be found more rewarding to observe the similarities between the species' diets than to speculate on the differences.

1. METHODS OF DATA COLLECTION, ANALYSIS AND INTERPRETATION

The contents of this paper are the result of spare-time study over the course of the last 15 years, and the bulk of the food records have been derived from the collection and analysis of stomach contents and faeces of robins.

This method is in marked contrast to that used for example by Tinbergen (1960). In his classic studies of the food of tits in the pine woods of Holland, all food given to nestlings was visually identified at very close range. Field conditions are very different in Africa however, the forest ecosystems are vastly more complex, and the species dealt with in this study are generally shy and furtive in their behaviour, so much so that the nests of two of them are still undescribed.

The analysis of stomach contents gives the most complete picture of dietary preferences of different species in different areas and seasons and of the size of food eaten. But this involves killing the bird, a course of action which for many reasons is undesirable. As will be shown, the prey spectrum is wide and varied, and robins are not at all numerous, so that the size of a statistically satisfactory sample necessary from any one area would virtually require destruction of the complete robin population. Consequently, where specimens have been killed purely for food study as opposed to taxonomic or other purposes, collections have been limited, the purpose being to discern trends rather than to provide a sample large enough for statistical significance.

A technique capable of yielding comprehensive results with none of the disadvantages associated with killing the bird lies in the microscopic examination of faeces. Of the 570

samples analysed in the course of this study, 300 have been faecal samples, or roughly 53%. Whilst a single faecel pellet is necessarily small in size and usually comprises very fragmented material, it nevertheless contains a cross-section of the food the bird has been eating, and the only difficulty that presents itself in analysis is the identification of insect sclerites and other remains. The task is made easier by the fact that robins tend to take a lot of very small prey, and because wings and heavily sclerotised portions are not digested. Beetles are relatively robust insects and elytra or fragments of them provide unmistakable proof of identity. In the case of ants, head capsules and thoracic portions are distinctive. Termite mandibles are an indestructible clue to the presence of Isoptera, and so on. When fruit has been eaten the whole sample sometimes takes on the stain of the fruit, but in any case portions of pericarp or aril or whole small seeds are usually found in the faeces.

All samples collected in the field are placed into dental anaesthetic tubes containing 70% alcohol. The alcohol preserves the sample indefinitely and the liquid medium facilitates subsequent microscopic examination.

The analyses of samples in the present survey have been divided more or less evenly between Mr C. N. Smithers, Mr B. R. Stuckenberg and the author. Samples are subjected initially to a magnification of $\times 10$ for gross identification and to higher magnifications for finer detail; lepidopteran wing scales are usually very small and best detected under a $\times 50$ lens. Any seeds in the sample can be compared with a named seed sample collection and can usually be identified quite precisely; for example, small *Ficus* seeds are distinguishable at species level under a low-power microscope.

The analysis of faeces has great advantages in that the diet of an individual colour-ringed bird can be followed from season to season. In such cases, all samples collected from one bird on one day are combined and treated as a single sample.

The following technique for obtaining samples from captured birds has been employed to advantage. After release from the net or trap the bird is placed loose in a shoe-box which is then closed and secured. The bird is left in the box for from 10 to 15 minutes before being allowed to fly free. During this period the bird invariably defaecates at least once, and may also regurgitate seeds or a pellet of insect sclerites. The box is lined with a clean sheet of paper for each bird to prevent contamination of one sample by another with such things as wing scales.

It was at first thought that faecal samples would contain only the remains of well-sclerotised prey, and analyses would tend therefore to give a biased picture of the prey spectrum. However, comparison with stomach content analyses shows that the two sample types correspond very closely, and no prey item found regularly in stomachs has not been identified also in a faecal sample. Indeed the only discrepancy of note concerns earthworms (Oligochaeta) which are taken by robins under certain circumstances but which have not so far been found either in stomachs or faeces. Normally, the integument of soft-bodied insects appears to survive in part or in whole in the digestive processes of the bird.

Field observations are useful in supplementing dietary records, but by their very nature tend to give only part of the picture. Few insects can be recognised with assurance when seen in the beak of a bird any distance away. If a bird is picking up prey regularly in a single spot it is easy to examine the area and identify the prey. Fruit is especially easy to identify from field observation by reference to the tree or plant from which it was obtained,

with the result that the subjective impression is formed that fruit is a more important constituent of the diet than is indicated by the examination of stomachs and faeces.

This factor introduces one of the basic difficulties of interpretation of data. A qualitative assessment cannot be adopted as it would be extremely speculative to suggest that one type of food was a more *important* source of nutrition than another, particularly in view of the virtually complete lack of data concerning the true food value of different foods and the nutritive requirements of the different species of birds at different times of the year. So a quantitative assessment must perforce be employed, but difficulties are still encountered. For example, one beetle, 12 mm in length, has about the same bulk as approximately 250 ants each 3 mm long. It is quite usual to find both in the stomach of one robin, and if the figure for ants were to be expressed as a percentage of the number of insects in the sample, its value would be 99·6%, relegating the beetle to 0·4%. This does not present a valid picture of the part played by the beetle in nourishing the bird.

Further to complicate matters, the majority of invertebrates in samples is well broken up, and it is often quite impossible to identify insect fragments with certainty, let alone to decide how many whole insects the fragments represent. Under these circumstances the procedure followed has been to list the presence of a type of insect (usually at the level of Order) in a sample irrespective of its numerical representation in that sample, and then to express its importance in terms of the percentage of samples in which it was found to be present. This is in any case the only type of assessment that can reasonably be made when dealing with faecal samples, and whilst it may be said to minimise the importance of some food categories, bias tends to be eliminated when the sample size is large enough. Table 1 lists the different food categories and gives their percentage occurrence in the 532 samples collected from wild robins in the course of this survey.

The systematic treatment of the robins requires some explanation. Because the group studied is pan-African, the sequence of species follows the most recent arrangement of African birds by White (1962). White's generic treatment has been modified to the extent that *Erythropygia* is preferred to *Cercotrichas*, and *Swynnertonia* is upheld for the species *swynnertoni*. *Alethe anomala* and *A. archeri* are transferred to *Cossypha* as they form a superspecies with *Cossypha isabellae*. However, these three birds are behaviourally and morphologically distinct from both genera and are certainly not true Cossyphas.

Few references are made to subspecies in this paper, the samples being too small in most cases to detect significant differences in diet. Such differences are hardly likely to have developed anyway except where there is a very distinct difference in bill size, as in *Erythropygia signata*.

2. SOME GENERALISATIONS ON FORAGING BEHAVIOUR

With a few exceptions the robins obtain most of their food at or near ground level. Actual foraging behaviour varies somewhat from species to species, but in the most usual form of hunting the bird perches on a twig, limb or rock seldom more than one metre above ground level and from this vantage point flies down to capture invertebrate prey it has espied. Once on the ground, the bird may resort to leaf whisking (in the case of forest species) or extended and active searching of bare ground, this latter method being particularly prevalent in the scrub-robins inhabiting arid and semi-arid habitats. The majority of insects identified in the samples are of terrestrial species.

Though robins spend much of their time on or near the ground they are not restricted to the lower levels of the habitat, particularly in evergreen forest. Ascent into the mid-strata or canopy is not at all infrequent, particularly by the true Cossyphas and *Pogonocichla*. This is not surprising in view of the fact that a high perch is usually sought when singing, and if a species is prepared to sing from the canopy there is no good reason why it should not also feed there on occasion. Certainly some of the fruits eaten by robins can only be obtained at such levels, and the leafy crowns of trees are good hunting-grounds for caterpillars, arboreal ants and termites. Robins tend to be very quiet when feeding, so their presence in the canopy is easily overlooked.

Finally, it may be noted that they are adroit fliers and can readily employ a range of foraging techniques from capturing flying prey on the wing to hovering in front of pendent twigs to take insects or fruit.

3. FEEDING ASSOCIATIONS

Robins are not by nature gregarious species and are normally solitary feeders. Observations of colour-ringed Cossyphas and the Starred Robin indicate that the pair bond is strong and male and female may be seen on occasions feeding in close proximity; more frequently, however, they feed out of sight of each other.

Perhaps because of this antisocial nature, reinforced on occasion by strong territorial drives, robins are relatively seldom found associating with the mixed parties of primarily insectivorous birds which are so much a feature of African woodlands and forests. When they do attach themselves to such parties, it is usually only for as long as it takes the party to move through the robin's particular territory or home range. Opinions differ as to the function of these mixed flocks of birds, which the present author has discussed in detail elsewhere (Oatley, 1969). It would seem however that the advantages accruing from membership of such flocks are not sufficient to entice robins to join them at all regularly.

The situation is quite different in relation to other forms of 'beating' however. A robin will stay with a working mole-rat (Bathyergidae; *Cryptomys* sp.) all day, feeding on the invertebrates disturbed from surface soil and leaf litter by the subsurface movements of the fossorial mammal. This behaviour has been noted on the coast of Natal and Zululand, in evergreen forest on sandy soils, the species *C. natalensis*, *C. dichroa* and *E. signata* being involved.

Other mammal beaters are more casually used. In South Africa many farmers are in the habit of driving their cattle into evergreen forest for browse during the winter months, and Chorister Robins regularly associate with the cattle within the forest confines (and on one occasion outside of the forest) to catch insects disturbed by the beasts. They do the same with Bushbuck, *Tragelaphus scriptus*, and I have one record of a Chorister Robin associating with a Blue Duiker, *Cephalophus monticolus*, perching close to the little antelope and following it as it wandered slowly through the forest. Van Someren (1956: 304) records a very similar observation involving *Cossypha semirufa* and the Suni Antelope, *Nesotragus moschatus*, in Kenya: 'I have also seen a Cossypha hopping behind a suni as it walked about the forest disturbing insects which the bird promptly snapped up.' The recording of such associations is rare, due to the wary nature of most forest antelope, but the habit on the part of the robins is probably quite regular.

TABLE 1

Food Category	*No. of species eating this type*	*No. of samples in which found*	*% occurrence in total samples*
ORTHOPTERA ..	18	93	17·5
(incl. roaches) ISOPTERA	14	147	27·6
HEMIPTERA ..	19	99	18·6
LEPIDOPTERA ..	20	220	41·4
DIPTERA	17	62	11·7
COLEOPTERA ..	22	384	72·2
FORMICOIDEA ..	21	376	70·7
other HYMENOPTERA ..	17	68	12·8
other INSECTA	8	13	2·4
CRUSTACEA.. ..	4	14	2·6
ARANEIDA	18	93	17·5
other ARACHNIDA ..	15	24	4·5
MYRIOPODA ..	14	58	10·9
MOLLUSCA	2	3	0·6
VERTEBRATA ..	3	4	0·8
FRUIT	13	159	29·9

Occurence of types of food in the total of 532 samples collected from 22 different species of wild robins in the course of this survey.

TABLE 2

	Time intervals						*Total*
	A	B	C	D	E	F	
GROUP 1 (0–3)	7 (6·2)	4 (8·4)	5 (11·4)	11 (9·6)	5 (7·8)	25 (13·7)	57
GROUP 2 (4–6)	9 (13·2)	21 (18·2)	29 (24·6)	19 (20·7)	21 (16·7)	24 (29·5)	123
GROUP 3 (7–9)	11 (7·6)	12 (10·4)	16 (14·0)	12 (11·8)	8 (9·5)	11 (16·8)	70
Totals ..	27	37	50	42	34	60	250

Contingency table to test for association between feeding intensity of robins and time intervals. Groups 1 to 3 represent low, moderate and high feeding intensity based on amount of food in stomach at time of death. Time intervals A to F represent two hour periods, starting at dawn and ending at dusk. The value for x^2 is 25.51 which is significant at the 1% level.

By far the most significant beating agent though is the Doryline driver ant (species of *Dorylus*, subgenus *Anomma*). The foraging activities of these ants never fail to attract robins and it is not at all unusual to find several representatives of three or more species present in the vicinity of an ant column. The leaf litter in the van of such columns is often audibly alive with insects of many types making haste to escape the advancing ant hordes, and it is these insects, rather than the ants themselves, which the robins feed upon. Such ant columns are a regular dry season feature of evergreen forest (both lowland and montane) north of the Limpopo. In South Africa the driver ant (usually *Dorylus helvolus*) is more of a subterranean forager, keeping out of sight below the ground surface or leaf litter, but the result is much the same, with insects and earthworms emerging to escape the ants and providing a good repast for the attendant robins. These ants usually move slowly and in the author's experience do not forage in the same area for more than one day; it is uncanny how the robins detect them, because it has been evident where the birds are colour-ringed that the individuals present are usually drawn from quite a wide area and do not only comprise the residents of the immediate neighbourhood.

4. DIURNAL FEEDING RHYTHMS

In considering the daily feeding rhythms of birds, a distinction has to be drawn between birds which must actively search for animal food and those which subsist largely on plant food. In periods of severe food scarcity a bird may have to spend all its waking hours searching for sustenance. Any improvement in such a situation will permit a bird to devote time to other activities in direct proportion to increasing food availability. Snow (1962) has shown that some manakins in Trinidad can find all their food in less than 10% of the daylight hours. Birds which feed on insects are likely to be influenced in their feeding-times by insect movements, which in turn are very much subject to the effects of three physical environmental factors, temperature, light intensity and humidity. So food availability is a product of food abundance and a varying number of other factors.

It is logical to suppose that a bird will spread its food intake over the available daylight hours, but the extent to which species do this is conjectural. In a paper based on the analysis of stomachs of 80,000 Nearctic birds, McAtee (1932) stated that 'Birds feed more or less constantly'. This conclusion was based on the fact that freshly taken food could invariably be found in a bird's stomach, irrespective of the time when it was killed. This approach, however, fails to make a distinction between casual or opportunist feeding and high-intensity feeding, both forms of which are practised by African robins. Opportunist feeding occurs when a bird, which is not engaged in feeding, fortuitously happens upon a food item and cannot resist the urge to consume it. For example, a Chorister Robin, which had been kept under observation for nearly an hour, had spent that time on one perch, sometimes preening but mostly just sitting. A falling leaf disturbed from rest a small white moth which fluttered to within 50 mm of the bird's beak. The robin casually leant forward, caught the blundering insect, swallowed it, and went on sitting.

The fallibility of field observations for recording feeding periods was highlighted when birds which had been kept under observation at ant columns for an hour or more and were apparently feeding were shot: their stomachs proved to contain surprisingly little. This was particularly noticeable during the afternoon hours. The presence of many individuals

of one species in a limited area perhaps results in stress conditions and gives rise to displacement activity in which false feeding is frequently resorted to. Cossyphas are particularly intolerant of one another's presence, and Natal Robins, for example, indulge in a great deal of pursuit. An alternative or additional explanation is that robins do not feed much in the afternoon and can afford to be highly selective when attending an ant column.

In order to learn about the feeding rhythms of robins, special attention has been paid to the amount of food found in the stomachs of birds killed. The time of death is noted, and the koilin lining complete with contents is removed intact from the ventriculus. The filled capacity of the sac is then arbitrarily scored according to a scale of eighths, or 1 to 8, with zero scored if empty, and 9 if overflowing. This yields ten classes of stomach bulk. This method is preferable to volumetric displacement inasmuch as the species size does not effect the result and in any case this technique can be rapidly employed in the field.

At the present stage of the investigation there are not enough samples for individual species analysis, but the combined number of samples from all species (excluding those of attended juveniles which are fed virtually continuously) is 250. For the purposes of statistical analysis all sample times were corrected to a standard 12-hour-day length and allocated to appropriate time periods. A contingency table was set up to test for association between feeding intensity and time intervals (Table 2). More time intervals would have been desirable, but because of the distribution of samples would have resulted in the expected values in some columns being too small for reliability. The samples have been divided into three groups which, on the basis of stomach content bulk, may be taken to represent low, moderate, and high levels of feeding activity. The scoring of samples for the ten categories is as follows: 0/1; 1/6; 2/20; 3/30; 4/45; 5/34; 6/44; 7/34; 8/32; 9/4. It will be seen that the bulk of the samples fall into the middle and higher categories. The smaller figure for category 5 may be due to the fact that it is an awkward bulk to classify and some samples which properly belonged in it may have been assigned to either 4 or 6, but the combination of these three categories into Group 2 effectively eliminates any bias.

From the distribution of the samples above it would appear that feeding is fairly continuous. The contingency table, however, yields a value for x^2 of 25·51, which with ten degrees of freedom is significant at the 1% level. It is improbable therefore that feeding is random with respect to time.

In Table 2 it will be observed that the greatest departures from expected values occur in the final column, F, where feeding intensity is markedly low: in fact, nearly 50% of the Group 1 samples occur in this column. The evidence gained from field observations is that robins, irrespective of species, feed most actively in the early morning, at around noon, and finally in the twilight period at dusk. This last is the most intensive feeding period of all and is usually no more than 20 minutes in duration. At this time many robins venture out of the forest into glades, roads, or other clearings, and are actively catching invertebrates at a time when the light intensity has declined to a point where colour is no longer discernible to human eyesight and only movement can be seen. This crepuscular period is of course the time when a great many insects and arachnids emerge from places of concealment and move about. If there were enough samples for column F to be subdivided four times, this intense activity would be well reflected in the last subdivision.

It appears that light intensity may be the prime factor in influencing feeding behaviour

at any time of the day, through its effect on terrestrial insect movement. Foraging activity by robins seems more frequent and prolonged on cloudy days than it does on sunny days. In many forest habitats the diurnal march of light intensity on sunny days, measured on the forest floor, does not show a flat-topped curve when plotted (as it would under an open sky) but is strongly bimodal with morning and afternoon peaks and a long period of lower intensity during the middle of the day (Haddow & Ssenkubuge, 1963). This is because the canopy permits a greater passage of slanting rays from the sun than of vertical ones. The morning and afternoon peaks vary in duration, depending on the aspect of the forest. In the forest studied in Uganda the peaks were from 0830 to 1100 hours and from 1400 to 1630 hours. The large flecks and splashes of sunlight on the forest floor at these times inhibit the movement of shade-loving and litter-dwelling insects, and could conceivably cause a reduction or cessation of foraging behaviour by robins which, like the insects they hunt, are great skulkers.

5. THE FEEDING HABITS OF A TAME ROBIN

In the course of general studies of robins, some nestlings of two species were hand-reared for the purpose of growth and development studies. One of these birds was a Heuglin's Robin, which on being released at an age of 18 months set up its territory in the garden. Because it was tame, it did not object to close observation of its feeding behaviour. Apart from faecal analyses (29 were made) it was possible to test its reaction before and after release to different types and sizes of food, and to make observations on hunting ability and technique.

One of the main characteristics of the young robins (*Cossypha humeralis* and *C. heuglini*) in captivity was that they seldom attacked flying prey. They quickly learnt to capture flying insects trapped against the inside of a window or mosquito netting, but these were of course unnatural circumstances. By contrast, running or jumping insects would be pursued and caught with alacrity. The same held true for this Heuglin's Robin which fended for itself until its accidental death $4\frac{1}{2}$ years after release. With the exception of termite alates (which are slow fliers) flying insects were seldom pursued; most winged insects were detected and captured when at rest. The ability of the robin to detect and identify motionless prey was remarkable. In particular it was capable of espying at distances of a metre or more resting moths which (to the writer) were well camouflaged.

This robin ate a great number of very small insects, including ants, minute beetles and aphids. One regurgitated pellet also contained two minute molluscs, a prey category not recorded yet from wild *C. heuglini*. It was especially fond of small *Tetramorium* ant workers which used to emerge and wander around on the flagstones about the house just before dusk.

It was not averse to taking large insects, however, provided they were not too formidable. Centipedes were a delicacy and it would subdue and consume any up to 60 mm in length. I once presented it with a large specimen over 100 mm in length which it looked at speculatively but left alone.

If confronted with a variety of live Arthropoda of small size (up to 20 mm long) the robin usually caught and ate the fastest moving ones first, irrespective of type. In general, roaches, crickets, spiders, isopods, centipedes, scorpions, moths and maimed flies were all

taken with impartiality. Small earthworms were relished but millipedes were seldom eaten. Adult beetles were usually eaten, unless capable of cantharidin secretion; beetle larvae were invariably acceptable. A live adult frog (*Arthroleptis* sp.) was once offered and was seized and swallowed immediately.

Although taste is generally held to be poorly developed in birds, it seemed to play an important part in the assessment of new 'food' by this robin. Being tame, it was conditioned to artificial foods, having been partly reared on a patent supplementary bird food. Any new potential food item which it found or had offered to it was seized, held in the tip of the beak, and touched with the tip of the tongue several times in rapid succession. The item was then either accepted or rejected.

The treatment that captured insects were given varied according to type; those armed with stings or capable of secreting distasteful substances would be well beaten before consumption, whereas inoffensive insects would be swallowed directly. The beating treatment is entirely instinctive, it seems, and perhaps triggered by taste sensation. When the robin was still a juvenile (about 50 days old) it was fond of eating small sections of cooked spaghetti. Plain spaghetti would be picked up and swallowed in one movement, but if the segment was experimentally dowsed in red pepper sauce the bird would proceed to kill it very thoroughly and roll it about on the floor before eventually swallowing it.

6. SIZE OF FOOD EATEN

The invertebrate prey of robins is generally of small size. The ants and termites are of course relatively small insects, but within these groups, smaller species dominate the prey list (see section 19). Many of the beetles eaten are also small, usually 5 mm or less in length.

Unfortunately the grinding action of the muscular stomach completes any dismembering of an insect initially inflicted by the beak, and the larger the insect, the less likely it is to be intact and measurable. Out of all the samples, only 243 arthropods (excluding ants and termites) were found sufficiently intact to be measured, the range in length being 2–70 mm, with a mean of 14·4 mm. The largest single items were a millipede 70 mm long and a hawk-moth caterpillar 50 mm long. Caterpillars are more easily measured than other insects because their integument, combining both strength and pliability, is not so easily fragmented by the mechanical action of the stomach. The mean length of 70 caterpillars measured was 16·5 mm; 48 adult beetles averaged 10·3 mm and 7 centipedes averaged 22·9 mm.

Naturally the larger robins can swallow larger items and the breadth is more important than the length in this regard, but is seldom measurable. The largest robin dealt with here, *Cossypha dichroa*, can swallow arthropods or fruit up to 12 mm in diameter.

7. PREY SPECTRUM

If a robin chances upon concentrated numbers of a palatable insect it usually exploits the find to full opportunity. This is well illustrated by high numbers of ant or termite workers often found in single stomach samples. Other samples which illustrate this point are as follows:

126 crickets (*Erythropygia leucophrys*)
42 crickets (*Erythropygia quadrivirgata*)

110 small scarabaeid beetles (*Erythropygia signata*)
71 small stingless bees (*Pogonocichla stellata*)
59 complete caterpillars (*Cossypha dichroa*)

Normally, however, stomach contents contain a fair variety of food items. This is to be expected since, even in temperate regions like the Palaearctic, birds take a relatively wide range of foods. This is advantageous as it distributes exploitation over many prey species and tends to damp out oscillations in their numbers such as would occur if the predators were more specific (Tinbergen & Klomp, 1960). In the tropics, where species diversity is greatly enhanced but individual numbers are smaller, the hunting bird will fill its stomach much more rapidly by exploiting variety than by narrowing its search to a few species.

In terms of broad categories alone, up to nine of the food classes listed in Table 1 have been found in some stomach samples, and the average number of classes represented in 267 samples is 4·1. But even a sample with only one class, for example Coleoptera, may contain insects of several species. Table 3 lists the species representation in the different food classes found in the most comprehensive single samples from each of 18 species of robins.

8. THE TAKING OF FRUIT

Most robins apparently eat fruit to a significant extent, though the amount taken by different species varies and depends on habitat and locality.

In England it is known that starlings and blackbirds inflict the greatest damage on ripening soft fruits in June and July when these birds are unable to find soil litter invertebrates during drought conditions (Murton, 1968), but there is as yet no real evidence that robins in Africa feed on fruits because of reduced availability of invertebrates at any time. In south-eastern Africa most fruit-eating by robins occurs during the dry winter months, the time when fruit is most available. It may be reasonably assumed that any decrease in the availability of invertebrates must occur during months of low temperatures and low humidities, and a subjective view would suggest that fruit is being eaten to compensate for reduced insect intake. Against this, however, must be weighed the fact that robins take fruit at any time of the year. The most simple explanation would appear to be that robins eat fruit because they like to, not because they have to!

In support of this, the analyses of three stomach samples of *Cossypha caffra* may be mentioned. In order to investigate food preferences, three adult Cape Robins were killed in two days, one from each of three different habitats in the space of a few square miles in the Drakensberg foothills of Natal. Collection times were selected to correspond with likely intensive feeding periods and in fact all three stomachs were completely full. The month was June and climatic conditions were characterised by sunny mild days and cold nights.

The first bird was collected in a mixed stand of wattle (*Acacia* sp.) and gum (*Eucalyptus* sp.) of several acres extent. The only food plant in the area was bramble (*Rubus* sp.) which was not in fruit at that time of the year. The vegetation was thus exotic in nature, poor in species variety, and the leaf litter was relatively dry. The stomach contained insects only, mostly beetles and ants, with some five species being represented.

The second bird, collected the following morning, was shot in a small stand of wattle mixed with indigenous scrub. The stomach contained insects of eight species and five seeds from an indigenous fruit, probably a *Rhus*.

TABLE 3

Numbers of species representing different food classes found in single stomach samples from robins.

	E. paena	*E. leucophrys*	*E. barbata*	*E. quadrivirg.*	*E. signata*	*Sh. gunningi*	*P. stellata*	*Swynnertonia*	*C. humeralis*	*C. bocagei*	*C. archeri*	*C. anomala*	*C. polioptera*	*C. natalensis*	*C. caffra*	*C. heuglini*	*C. dichroa*
ORTHOPTERA	1		1	1		2					1			1		1	1
ISOPTERA	1	2	1	1				1	1							1	
HEMIPTERA	2		2			2		1	1		1	1	2	1		2	
LEPIDOPTERA	2	1		3	3	1	1		2	1	1	2	1	2	3	1	
DIPTERA							1			2			1	1	4		1
COLEOPTERA		1	3	3	4	3	4	5	1	2	4	5	4	4	4	3	3
FORMICOIDEA	4	6	1	1	1	2	2	1	4	2	1		2	2	1	2	1
other HYMENOPTERA			1				1			5		1		1	1	3	
other INSECTA							1	1									
CRUSTACEA																	1
ARANEIDA	1		1				2	1	1	1	1	1		3			
other ARACHNIDA							1					1			1		
MYRIAPODA					1							1		1			2
MOLLUSCA												1					
VERTEBRATA																1	
FRUIT		1					1					1			1		
TOTALS ..	11	11	10	9	9	10	14	10	10	13	9	14	10	16	15	14	9

The third robin, shot shortly after noon on the same day, was collected in a remnant indigenous forest, growing in a narrow gorge on a mountain side. In this habitat the soil moisture level was high and the forest floor was strewn with deep litter. The stomach of this bird contained invertebrates of nine different species but at least half the stomach capacity was filled with small berries of three different plant species.

To summarise, the three habitats were characterised by an increasing variety of food resources, and in particular of invertebrates, which fact was reflected in the stomach samples, but the greatest amount of fruit was consumed in the area with the richest invertebrate fauna. All three birds were in good condition.

A systematic list of plants, the fruit or seeds of which are eaten by robins, is provided in Table 4. This list is by no means exhaustive and in any case refers only to Natal and the Transvaal. Those robins known to eat the fruit in question are indicated; in general though, if a fruit is eaten by one species of bird it will also be eaten by all others with frugivorous tendencies, within the limits of size and distribution.

There are no records of robins eating grass seeds with the exception of two *Cossypha heuglini*, both collected at the same locality in Zululand. In both cases, however, the birds had been eating large quantities of *Pheidole* ants which were harvesting the grass seeds in question, and the ingestion of these seeds by the robins was likely to have been quite accidental.

Fruits or seeds of fruits with thick aril are usually plucked from the plant. *Cossypha caffra* and *C. humeralis* frequently feed from fallen fruits however, and the latter species will pick up seeds, like those of *Antidesma* from the ground. Only very small seeds are passed through the digestive tract; seeds from about 2 mm diameter upwards are regurgitated after the fleshy fruit or aril has been ground off in the muscular stomach.

9. NECTAR FEEDING

Nectar feeding in Africa is practised by many birds not specialised in such behaviour, and in such cases *Aloe* probing is the form of nectar feeding most resorted to. The only robin observed to indulge in this behaviour, however, is *Erythropygia leucophrys*. These scrub-robins have been observed feeding on the nectar of *Aloe marlothii* in the winter months in north-eastern Zululand (Oatley, 1964). It is by no means a regular habit, however, and this food source is not a significant one for robins.

10. GRIT INGESTION

There is no evidence to suggest that robins deliberately ingest grit or stones in the manner of many graminivorous birds as an aid to grinding up food for easier digestion. As already mentioned, seeds are usually regurgitated by robins, only the soft parts of fruit being used as foods; seeds as such form no part of the diet and do not therefore need to be ground up.

Fine quartz may be found in a robin's stomach, particularly in sandy areas, due to accidental ingestion in the course of capture and subjugation of terrestrial prey. Such grit is voided with the faeces and never builds up to large quantities in the stomach. Table 5 shows, amongst other things, the frequency with which grit was voided in this way by one individual bird.

TABLE 4

PLANT SPECIES	*E. leucophrys*	*P. stellata*	*C. humeralis*	*C. natalensis*	*C. caffra*	*C. dichroa*
Asparagus falcatus					x	
Asparagus asparagoides ..						x
Celtis africana					x	x
Ficus capensis					x	
Ficus sycamorus		x				
Xymalos monospora						x
Erythroxylon delagoensis ..				x		
Vepris undulata						x
Capparis tomentosa			x			
Antidesma venosum			x			
Cestrum aurantiacum ..					x	
Rhus fraseri					x	
Ilex mitis		x			x	
Maytenus harveyana					x	x
Grewia microthyrsa			x			
Kigelaria africana		x				
Cassipourea gummiflua ..		x				
Scolopia mundii						x
Euclea daphnoides			x	x		
Euclea divinorum			x			
Vitex sp.	x					
Solanum mauritianum ..					x	x
Canthium sp.		x				
Scutia myrtina						x
Halleria lucida		x		x	x	
Burchellia bubalina						x
Rhus succedanea		x				x
Morus sp. (Mulberry) ..					x	
Psidium pomiferum (Guava)..					x	x
Hedychium flavum		x			x	x
Physalis peruviana					x	
Lantana camara						x
Rubus sp. (Blackberry) ..					x	x

List of trees and shrubs which provide fruit eaten by robins in Natal and Zululand. Those species observed eating the fruits in question are marked off in the right hand columns. The lower seven plant species are all exotics, mostly cultivated.

The only published record of deliberate grit ingestion concerns the Cape Robin, *Cossypha caffra* (Eaton, 1922). A pair of birds with young in the nest were observed to roll 'grubs or worms' in a patch of dry sandy dust before offering them to the nestlings. This was done 'four or five times a day'. A possible reason for rolling prey in dust in such a manner could be to dry off slimy or sticky exudations and thus facilitate the swallowing of the food by the nestlings.

11. DRINKING

Drinking is discussed here since it is in many birds necessitated by lack of moisture in the diet. As a general rule, however, insectivorous birds (as opposed to seed-eaters) can obtain enough moisture from their food to be able to subsist without drinking, and do not drink even when water is available. This would appear to be the case with the Kalahari Scrub-robin, *Erythropygia paena*, which is well adapted to its life in arid regions and is not known to join other desert birds at waterholes. The same would appear to be true of other members of the genus, even the forest-dwelling species, as I have no records of any of these robins drinking.

By contrast, some of the Cossyphas are regular drinkers, and this behaviour has been observed in *C. caffra*, *C. natalensis* and *C. dichroa*. There are no records of drinking by *C. humeralis* or *C. heuglini*. *Pogonocichla stellata* drinks, though not frequently. It must be noted that a visit by a robin to a stream, waterhole or bird-bath does not necessarily indicate that it is thirsty, for most robins are inveterate bathers and the majority of visits to water are made for bathing purposes.

Observations on drinking in Natal have been made mainly between the months of April and September (the driest months of the year) in evergreen forests both at high altitudes and on the coast. It is not to be supposed that drinking is essential for all species mentioned above. The primary habitat of *Cossypha natalensis* in Natal is evergreen forest on consolidated sand dunes along the coast; although flanking lagoons in many places, the bulk of the dune forest is devoid of surface water. The situation of *Cossypha dichroa* is very different however. This robin avoids dry habitats, eats more fruit than most other robins, yet still drinks deeply and with great frequency during the dry season. It seems most likely that this species has difficulty in maintaining its moisture balance during periods of low humidity. If this is the case, water intake is not dictated simply by a shortage of insect food, but is a physiological characteristic of the species.

12. INDIVIDUAL DIET: VARIATION AND CONSISTENCY

Tinbergen (1960: 318) demonstrated differences in the food taken by individual Great Tits, *Parus major*, in Holland, and showed that such differences could be caused by differences in availability of prey (related to habitat differences), choice of strata in which the birds fed, and differences in feeding technique. It is likely that all three factors are singly or collectively applicable to African robins.

Manifestation of individuality in feeding habit is seldom detectable by field observation except in nectar feeding where *Aloe* pollen colours facial plumage and only one of a pair of birds may have an orange face. To detect individual differences, it is really necessary to have samples from identifiable birds feeding in the same area during the same time

period. The only approach to this in the present data is provided by a series of five and seven faecal samples respectively from two colour-ringed Starred Robins, 'Yellow' and 'Green', which frequented the author's garden during the winter of 1968. Both birds shared a predilection for beetles, ants and fruit, and ate similar quantities of these foods, but Green took moths, bugs and spiders twice as frequently as Yellow and also ate small isopods. Green happened to be a resident bird whereas Yellow was only a winter visitor, and it is conceivable that Green knew the area better and was in any case the dominant bird by virtue of residence.

When comparing such samples, collected over a period of weeks, one has to assume reasonable consistency in the diet of the individual. The opportunity to investigate this subject occurred when the roost of a Cape Robin was discovered in woodland in Winterskloof in June 1966. The roost was used frequently from the time of discovery until 22 July, and as the bird always perched on the same short twig it was possible to place a board underneath and so collect all the faeces voided during the night. These were collected each morning (with three exceptions) and analysed as composite samples. The results are set out in Table 5. It can be seen at a glance that the staple diet comprised beetles, ants and fruit, with other categories providing little more than occasional variation. Most of the beetles eaten were very small weevils, but a 10 mm long elaterid and two tenebrionid beetles were also identified. Ant species comprised mainly small Myrmicine workers, *Pheidole* sp., but *Dorylus* sp. were present in three samples. Fruit was always represented by varying numbers of seeds of *Solanum mauritianum*, a common tree in the area. Other fruits were available at the time but there was no evidence to suggest that they were eaten by this bird (regurgitated seeds would have been found on the collection board as well as faeces).

It should be noted that these samples reflect the content mainly of the final meal of the day, which may account for the low representation of some of the insect categories. Nevertheless the overall impression to be gained is that the robin fed consistently on the same types of food for the six-week period during which the samples were collected.

13. SEASONAL VARIATION IN DIET

Some food types are largely seasonal in their availability whilst other types are continuously available. The degree to which the latter resources are exploited depends on their abundance relative to other food types, bearing in mind that a bird attempts always to vary its diet.

In regions with well-defined wet and dry seasons (which includes most of Africa) it is generally true to say that the variety of winged insects is greatest during the rains, and indeed all insects may be expected to be more numerous at such times. Robins, however, take relatively little flying prey, and it is obvious from the samples that their main food categories are always available. Seasonal variation is reflected mainly in the species eaten; for example, scarabaeid beetles are most frequently taken during the summer months, at times when they are most active.

Ecological factors can affect the availability of some insect Orders in some areas. In evergreen forest habitats of the Natal midlands, for example, termite workers are eaten only during the late winter months, when leaf fall from deciduous trees is greatest and the termites are active in the new litter layer.

TABLE 5

	JUNE																		JULY									Percentage Representation
	6	7	9	10	11	14	15	16	17, 18	19	22	23	24	25	26	27	28	29	1	2	3	4	6, 7	8, 9	10	11	22	
ORTHOPTERA									x																			3·7
ISOPTERA	x			x				x																				11·1
HEMIPTERA											x								x									7·4
LEPIDOPTERA	x				x						x						x	x	x	x					x	x		37·0
DIPTERA												x												x				7·4
COLEOPTERA		x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	92·6
FORMICOIDEA	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100·0
other HYMENOPTERA	x	x								x							x						x					18·5
ARANEIDEA											x		x												x			11·1
FRUIT	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	100·0
GRIT					x				x				x		x	x	x				x		x	x	x		x	40·7

Representation of food categories in 27 composite faecal samples collected from a roosting Cape Robin *Cossypha caffra* between 6 June and 22 July, 1967, in Winterkloof, Natal. Gaps in dates indicate bird absent from roost at those times. Most of the coleopterous remains comprised very small weevils. Fruit taken was in every case *Solanum mauritianum*.

Fruit varies widely in its availability and variety from one region to another. In particular it should be noted that some trees tend to follow individual calendars (*Ficus sycamorus* is a good example) so that every stage of the annual cycle may be represented in one place at one time. Quite apart from fruit availability, this phenomenon also has a profound effect on any insect communities related to the plant in question.

It may be accepted that seasonal variation in diet does occur to a greater or lesser extent, depending on ecological factors at work in any area where a robin is resident. But many robins are not resident, and quite apart from purely local movements, large numbers indulge in some form of altitudinal migration (Oatley, 1966). Quite obviously, a bird which moves between montane evergreen forest and low altitude riverine forest flanked by thorn scrub, must perforce undergo a significant change in diet twice a year. There is evidence to support this in the present samples. (See under *Pogonocichla stellata* in section 18.) Some idea of the extent to which habitat affects diet may be gauged from the next section.

14. COMPARISON OF FOODS TAKEN IN DIFFERENT VEGETATION ZONES

Moreau (1966*a*, 1966*b*) has stressed the need for a better understanding of food availability in each of the major vegetation zones in sub-saharan Africa. As the present study includes samples from four of the five major biomes, the opportunity is taken to compare the degree to which different food categories are exploited in the different zones.

The method adopted here has been to select stomach sample analyses from species which were collected in characteristic stands of the zones concerned, and to express the representation of food categories as percentage occurrence in the sample number. As the emphasis here is on food available in the different zones, the samples have been drawn from as many different species of robins as possible in order to eliminate any bias attributable to individual species' preference or hunting techniques.

The criterion for sample acceptance was that the species had to be feeding entirely within the confines of the habitat concerned when collected. This has limited the number of samples, particularly in woodland habitats; for example, birds feeding in evergreen gallery forests in the *Brachystegia* zone have not been included, even though some species like *Cossypha bocagei* make regular evening foraging excursions into woodland habitat.

Although Moreau subdivided the biomes, this has not been possible here because of sample deficiency, except in the case of montane evergreen forest, where a separate category, South-east African Temperate Forest, has been included. The samples for this category are restricted to those collected in forests in Natal and the Transvaal above 1,000 metres altitude. Although these forests are not strictly montane they are nevertheless similar in ecology and avifauna to true montane forest north of the Zambezi. The main difference is that these temperate forests are subject to a substantial dry season.

The species compositions for the different zone samples are made up as follows:

ACACIA: *E. paena*, 7; *E. leucophrys*, 9; *E. quadrivirgata*, 3; *C. humeralis*, 6; *C. heuglini*, 2; *C. caffra*, 1; *C. natalensis*, 2.

BRACHYSTEGIA: *E. leucophrys*, 9; *E. quadrivirgata*, 2; *E. barbata*, 3; *C. heuglini*, 2.

LOWLAND EVERGREEN FOREST: *E. quadrivirgata*, 2; *E. signata*, 6; *Sheppardia gunningi*, 7; *Stiphrornis erythrothorax*, 2; *C. natalensis*, 10; *C. cyanocampter*, 2; *C. dichroa*, 1.

MONTANE EVERGREEN FOREST: *Sheppardia aequatorialis*, 6; *P. stellata*, 9; *C. anomala*, 9; *C. archeri*, 10; *C. caffra*, 1.

S.E. AFRICAN TEMPERATE FOREST: *E. signata*, 9; *P. stellata*, 14; *C. caffra*, 1; *C. dichroa*, 6.

The comparisons of these samples are set out in Table 6. The sample for *Brachystegia* is unfortunately small and the figure of 6% for fruit is almost certainly too low because the majority of samples were collected in one region at a time when soft ripe fruits were definitely scarce (Oatley, 1969). Aside from this the figures all tend to be somewhat higher than average because of the smaller size of the sample.

Notwithstanding this, some interesting trends are evident. To some extent the figures are influenced by the species from which the samples are drawn, and of course the bulk of the samples from each zone are from species which are characteristic of it. But considering that birds tend to eat different foods in definite proportion to their respective availabilities, the figures may be taken to represent meaningfully the importances of the different food types.

The most striking features are the preponderance of termites in the first two columns: the value for fruit in the *Acacia* zone, and the virtual replacement of ants by Myriapoda in the last column, a result for which no ready explanation is apparent.

15. FOOD GIVEN TO NESTLINGS AND FLEDGELINGS

No close-up studies have been made at robins' nests in the course of this work and the only data on nestling diet is that which has been derived from analyses of faecal sacs and a few stomachs from nestlings found dead.

Faecal samples from nestling robins tend to contain far less identifiable matter than is normally found in adult samples. The food appears to be more effectively ground up and the samples contain a very high proportion of amorphous matter.

From these analyses, however, the indications are that young robins are fed on much the same sort of food as the adults eat, even ants being fed on occasion. There is a tendency toward a higher proportion of soft-bodied larval forms of beetles, and caterpillars and spiders are also regularly fed, but the samples are too few at this stage to draw definite conclusions. It may be mentioned that fruit is also fed to nestlings, though apparently not in large quantities.

Once the young robins are fledged, the adults continue to attend them for several weeks; again the usual range of foods is offered, and the young bird begins gradually to peck about itself and find food whilst the adult is away foraging. Small fruits are sometimes proffered to juvenile robins, and it is perhaps at this stage that they learn to recognise fruit as a potential food source.

16. THE FOOD OF IMMATURE ROBINS

Once independent of its parents, the young robin obviously learns about food palatability by a process of trial and error. Most instances involving the presence in samples of what are normally considered to be distasteful insects have concerned immature robins in their first year of life.

Harvester termites (*Hodotermes* sp.) are regularly eaten by many Kalahari birds, but the only sample from a species other than *E. paena* in which they were found in large

numbers was from an immature Cape Robin, *C. caffra*, which happened upon a foraging colony in Zululand and exploited it. By contrast I have on several occasions seen robins hunting busily in the close vicinity of foraging harvester termites without taking any interest in them.

Driver ants are seldom eaten in quantity by robins, the few that are found in stomachs usually being ingested accidentally when adhering to other insects captured by the robin in the van of the main ant column. The only robin (of all those studied here) to have numerous driver ants in its stomach (79 in all) was a first year Chorister Robin, *Cossypha dichroa*, collected in the northern Transvaal.

Presumably robins indulge in a good deal of experimentation in the early months of life when they are inexperienced and likely to encounter unfamiliar insects. It is interesting, though, that (in some cases at least) the insects are swallowed and not immediately rejected, so it may be assumed that they are not initially distasteful. Something must happen, however, to cause the bird to ignore them on future occasions, and this could perhaps be a degree of indigestion resulting in internal discomfort.

TABLE 6

	Acacia	*Brachystegia*	*Lowland forest*	*Montant forest*	*S.E. African temperate forest*
Sample number:	30	16	30	35	30
ORTHOPTERA	37	50	53	20	20
ISOPTERA	87	88	27	6	10
HEMIPTERA	53	44	20	34	13
LEPIDOPTERA	50	44	40	69	63
DIPTERA	—	6	3	26	23
COLEOPTERA	80	100	83	89	87
FORMICOIDEA	77	100	80	69	33
other HYMENOPTERA	10	25	17	43	7
other INSECTA	3	6	—	3	3
CRUSTACEA	3	—	3	—	7
ARACHNIDA	20	31	33	40	13
MYRIAPODA	13	—	33	23	60
MOLLUSCA	—	—	—	9	—
VERTEBRATA	—	—	7	3	—
FRUIT	30	6	7	17	17

Percentage occurrence of food types in samples from different vegetation zones

17. ABNORMAL FOODS

Inevitably, when living in the vicinity of human dwellings, robins will come across potential food items that do not exist in the more natural environment, and these may be exploited to a greater or lesser degree according to a variety of circumstances. Of all the species considered here, the Cape Robin, *C. caffra*, seems to adapt itself most readily to urbanization, to the extent that some individuals will enter houses for food, though this is a rare occurrence. In the garden they may visit the bird-table for bone-meal or the dog's dishes for *putu* (cooked maize). But the most popular processed food for any robin is undoubtedly butter, and the list includes egg yolk, cheese, rice, mincemeat, spaghetti and cocktail cherries!

18. ANNOTATED LIST OF THE ROBINS STUDIED

The birds are listed in systematic order following White (1962). The abbreviations S and F refer to stomach and faeces respectively and are followed by the number of samples of each for the species concerned. An average weight in grams is given for each species so that the relative sizes of the birds may be compared. There are few references in published literature to details of diet with the exception of Chapin (1953). All references to Chapin in the ensuing text refer to this particular work.

The percentage occurrence of food categories in the samples from each species is given in Table 7 for all species with six samples or more.

ERYTHROPYGIA PAENA Kalahari Scrub-robin S8. 19 g.

This species is a characteristic bird of low-rainfall *Acacia* habitat under semi-desert conditions mainly in the western part of southern Africa. In some parts of its range it occurs alongside *E. leucophrys*. Most of its food appears to be captured on the ground and termites and ants feature prominently in its diet. It is the only robin studied that regularly eats harvester termites (*Hodotermitidae*).

ERYTHROPYGIA CORYPHAEUS Karoo Scrub-robin S11; F1. 20 g.

A South African endemic, usually associated with Karoo conditions. My field experience of this robin is very limited, and it is included here on the strength of 11 stomach samples kindly collected by the staff of the Durban Museum during a field trip to the western Cape. Ants, in bulk as well as occurrence, were the most important prey category in these samples. Skead (1966) observed this species feeding in the intertidal zone on the Cape Peninsula.

ERYTHROPYGIA LEUCOPHRYS White-browed Scrub-robin S23; F25. 19 g.

The most widespread of its genus on the African continent, this scrub-robin is primarily a species of tree savannah and savannah woodland of low and moderate rainfall areas. Consequently it is found in *Acacia*, Mopane and *Brachystegia* woodlands, although commonest in the former. Termites appear to form the most important food category, and it knows well how to obtain these, regularly breaking open the earthen galleries formed about fallen twigs or leaves. It normally feeds on the ground and prefers short grass areas to those with long grass, though it is not averse to entering the latter, and even reed-beds, on foraging excursions. In Zululand one bird was observed foraging in fresh dung of a Black

Rhinoceros, *Diceros bicornis*, and other observations of a similar nature suggest that this habit may be well developed in Game Reserves and other areas with large herbivore populations.

ERYTHROPYGIA HARTLAUBI Brown-backed Scrub-robin S1. 19 g.

A single stomach sample of this species was obtained in the Kivu Province of the eastern Congo. The bulk of the stomach contents was of small beetles and beetle larvae, the other identifiable material being derived from a moth, a fly, a large homopteran (Fulgoridae) and a small millipede. This bird was feeding in scrub forest on a lava plain. Chapin specifically mentions only a grasshopper and a small millipede in the contents of three stomachs of this species.

This scrub-robin is of particular interest inasmuch as it is normally associated with large clumps, or areas, of elephant grass. A pair of these birds I watched in the Congo spent a whole afternoon in a patch of elephant grass only 10 metres in diameter, and they appeared to find all the food they required during that period without leaving its confines. In this regard it is interesting to note that Salt (1955) sampled soil fauna in elephant grass leys in Uganda and found the equivalent of 87,147 arthropods per sq. metre. Burnett (1968) compared these and other samples from pasture, cultivation and 'semi-arid grassland' in east Africa, and showed that the mean population of all Arthropoda is more than three times as high under elephant grass as the second highest, moist (irrigated) grassland, and more than twice as high as the latter with respect to populations of Isoptera and Formicoidea. A combination of excellent cover and comparatively rich ground fauna would appear to make elephant grass an attractive habitat, and it is not surprising that this species of robin has occupied it.

ERYTHROPYGIA QUADRIVIRGATA Bearded Robin S16; F5. 27 g.

Beetles and ants occur most frequently in samples from this species and termites, though still important, occur in less than half of the samples. Like *E. leucophrys*, this robin will break open termite galleries to get at the insects. Caterpillars appear to be eaten with more frequency than adult lepidopterans.

The Bearded Robin usually frequents forest in preference to woodland or savannah, and where it does occur in the latter it haunts the densest cover provided by thickets or riverine growth. It is not averse to feeding in the canopy of dry forests in Zululand, ascending to heights of 12 to 15 metres above ground level. Usually very secretive, it is prone to desert cover and emerges into paths or tracks in the last hours of daylight, as many robins do. It will be noted from Table 7 that there are no records of fruit-eating by this species.

ERYTHROPYGIA BARBATA Grey-backed Bearded Robin S3. 27 g.

This is an ecological species, a sibling of *E. quadrivirgata* of which for many years it was considered a race. The present species is virtually confined to the *Brachystegia* woodlands which cover much of Angola, Zambia and Tanzania. The contents of three stomachs from birds collected in Zambia all contained grasshoppers, termites, beetles and ants. Wasps, bugs and spiders were present in two of the three samples. Indications from this are that the diet is similar to that of its congener.

TABLE 7

	E. paena	*E. coryphaeus*	*E. leucophrys*	*E. quadrivirgata*	*E. signata*	*Sh. aequatorialis*	*Sh. gunningi*	*P. stellata*	*Swymmertonia*	*C. archeri*	*C. anomala*	*C. humeralis*	*C. polioptera*	*C. natalensis*	*C. caffra*	*C. heuglini*	*C. dichroa*	*Phyllastrephus terrestris*
Sample number:	8	12	49	21	27	6	7	93	9	10	9	38	6	47	105	28	44	15
ORTHOPTERA	37	8	18	29	30	50	57	12		20		11	33	34	10	14	9	20
ISOPTERA	100		69	48			57	11	22			42		26	35	21	7	27
HEMIPTERA	50		27	10	7	50	14	22	11	10	56	11	50	17	15	21	9	13
LEPIDOPTERA	50		31	19	30	50	57	57	33	80	78	37	67	34	46	32	34	33
DIPTERA		25	2	10	7	17		22	11	10	56	5	50	2	9	7	9	7
COLEOPTERA	62	75	59	76	59	50	86	78	89	90	100	63	100	79	67	75	73	87
FORMICOIDEA	62	100	67	71	63	83	71	52	67	80	67	55	83	77	88	86	61	27
other HYMENOPTERA		8	4	14	4	50	14	14		30	33		50	13	17	14	2	
other INSECTA			2					3	11					6	2	4	2	7
CRUSTACEA								8						2		7	9	27
ARANEIDA	12		12	24	4	33	71	28	22	20	44	18	17	21	12	4	5	40
other ARACHNIDA	12		2	5	4	17		1	11	10	33	5	33	2	4	7	5	
MYRIAPODA			4	5	48			13	11	30	22	3		13	4	11	16	
MOLLUSCA										10	22							13
VERTEBRATA							29				11					4		
FRUIT	50	33	10		7			28	11	10	56	13		13	65	25	57	87

The percentage occurence of food categories in all samples from each of 17 species of robin and one species of bulbul.

ERYTHROPYGIA SIGNATA Brown Robin S21; F6. 34 g.

The Brown Robin is essentially a species of moist evergreen forest in south-eastern Africa, ranging from sea-level in the Cape and Natal to altitudes of over 1,700 metres in the Transvaal. There is a very well differentiated subspecies *E. s. tongensis* which inhabits subtropical dune forest from St Lucia Estuary in Zululand north to the Limpopo in Moçambique. It deserves mention here since it has a very much shorter beak that is presumably connected with its feeding habits. Of the 27 samples for this species, 13 are of the short-billed race, and there is no obvious difference between the percentage occurrence of different food types in the two sets of data. The Brown Robin is entirely a ground feeder (except perhaps when taking fruit) and the only explanation that might account for the shorter bill of the Tongaland birds concerns the relatively shallow depth of leaf litter overlying the sand of the dune forest floor. Long-billed populations usually inhabit damp evergreen orests on clay soils where litter is often deeper.

The main components of the diet appear to be ants, beetles and millipedes in that order. The figure of 44% for the latter category is unique and is approached only by *Cossypha archeri* (an allopatric species). Only two out of 27 samples contained seeds from berries, and in four out of 29 skins in the collection of the East London Museum, 'seeds' or 'berries' are mentioned on the collectors' labels. The Brown Robin is a very silent feeder. One was observed attending a working mole-rat for nearly the whole of two consecutive days in a forest near Durban in July 1955.

SHEPPARDIA AEQUATORIALIS Equatorial Akalat S6. 17 g.

A species primarily of montane evergreen forest, the birds in this survey having been studied in the Rugege forest in Buganda and the eastern Congo. It appears to feed with equal facility in the undergrowth or canopy of the forest and is a regular attendant at ant columns. A full account of the observations had been published elsewhere (Oatley, 1961).

SHEPPARDIA GUNNINGI Gunning's Robin S7. 17 g.

A species of lowland forest with a very disjointed distribution pattern. The samples studied here are from the nominate subspecies in Moçambique (3) and the race *S. g. bensoni* in Malawi (4). The former were collected in November and the latter in May, and the difference in season and locality may account for the rather marked differences in prey choice of the two populations. All four Malawi birds had eaten termites and two had also eaten small frogs, neither of which appeared in the Moçambique samples. A larger number of samples will probably eliminate these differences. Irwin (1963) noted that the stomach of an adult collected in Moçambique contained beetles, ants and a grasshopper.

STIPHRORNIS ERYTHROTHORAX Orange-throated Forest Robin S3. 16 g.

This is the smallest of all the robins, and is a bird of the tropical lowland forests of west and equatorial Africa. It is normally solitary and is a regular attendant at ant columns. Marchant (1953) states that in south-eastern Nigeria this species is typically confined to the forest floor and is not usually found associating with mixed hunting parties of birds. Serle (1965) notes that only insects were found in 12 stomachs examined. Chapin, commenting on the contents of six stomachs, found that insects were always present and

TABLE 8

	ORTHOPTERA	ISOPTERA	HEMIPTERA	LEPIDOPTERA	DIPTERA	COLEOPTERA	FORMICOIDEA	other HYMENOPTERA	other INSECTA	CRUSTACEA	ARANEIDA	MYRIAPODA	FRUIT
HIGH ALTITUDE FOREST (MARCH–SEPTEMBER) 1,000 metres +	1	1	2	11	4	12	5	2	1	1	5	5	2
LOW ALTITUDE FOREST (MARCH–SEPTEMBER) Maximum altitude 500 metres	2	1	5	4	5	10	13	1	2	—	5	1	6

Comparison of 16 samples from *Pogonocichla stellata* resident in high forest with 16 samples from Starred Robins which had moved to lower levels for the winter months. The figures represent numbers of samples in which the categories were represented.

included some beetles, some termites and a single caterpillar. Three birds collected in the eastern Congo by the author had eaten (1) ants; (2) 18 mm caterpillar, small beetle larva, termites (18 head capsules) and an Acridid; (3) several small beetles; parasitic wasps and a small Acridid.

POGONOCICHLA STELLATA Starred Robin S41; F52. 20 g.

A more comprehensive cross-section of samples has been obtained for this species than for any other robin in this survey. The Starred Robin is often cited as a characteristic species of montane evergreen forest, but by virtue of well-marked altitudinal movement virtually throughout its range it is a seasonal frequenter of forest and woodland habitats at low altitudes. Of the 93 samples analysed here, 16 were from birds wintering in low-lying areas between March and September. These samples are extracted and compared with 16 samples from neighbouring high altitude forests for the same months in Table 8. There is a marked contrast between some of the figures, and in particular birds at low levels appear to eat more ants and fewer lepidopterans than those in the high forests.

There seems to be no difference between samples collected from different subspecific populations. Chapin, commenting on the stomachs of nine *P. s. ruwenzorii*, found no fruit, but all contained insect remains, beetles being often noted, small caterpillars in four cases, termite workers in one and a single driver ant in one (a juvenile). None of the eight birds of this race examined by the author had eaten fruit, but all were collected in the space of one week, so this negative result is not conclusive. The only other published reference to the food of *Pogonocichla* is by Van Someren (1939) who gives a comprehensive account of the habitats of the race *P. s. macarthuri* and writes: 'Most stomachs examined contained insects, either mature or in the larval stages, as well as spiders and small mollusca, and occasionally a few small berries.'

The Starred Robin probably takes more food on the wing than most other robins considered here, and this is not surprising for a bird originally described as a flycatcher. The mere presence of winged prey in stomachs or faeces is not necessarily indicative of fly-catching habits, of course, since such prey can be captured when at rest. However, the subjective impression from field observations indicates that a fair proportion of prey is taken on the wing.

SWYNNERTONIA SWYNNERTONI Swynnerton's Robin S5; F4. 17 g.

Most systematists consider this small robin as congeneric with *Pogonocichla*, but anybody really familiar with the living birds of both species will find it difficult to agree with such an arrangement. Swynnerton's Robin is a very localised species and seems to favour evergreen forest at altitudes of from 1,200 to 1,500 metres. It is a regular attendant at driver ant columns. Only nine samples have been available for analysis, and the results fit in well with those of other robins.

COSSYPHA HUMERALIS White-throated Robin S12; F26. 22 g.

The White-throated Robin is a species of thickets and dense cover in low to medium rainfall acacia areas of south-eastern Africa and extends in *Brachystegia* woodland in Rhodesia. There are no records of food in the published literature. Termites are important in its diet by virtue of its residence in woodland habitats.

COSSYPHA BOCAGEI Bocage's Robin S4. 21 g.

This species has been studied briefly in north-western Zambia where it occurs in hygrophilous evergreen forests along watercourses in *Brachystegia* woodland (Oatley, 1969). Beetles, ants and flies were represented in all four stomachs examined, wasps, bugs and spiders in three, and termites, a cockroach, lepidopteran wing scales and a Neuropteran occurred once only. One of the birds had eaten at least 20 small wasps of varied species and three Diopsid flies. The birds frequently ascend quite high into the canopy trees and in the area where studied were in the habit of leaving the forest on extended foraging excursions into the woodland at dusk. This bird is not a Cossypha, and there are good grounds for placing it with the genus *Sheppardia*. Certainly the apparent predilection for winged prey is more in keeping with the latter.

COSSYPHA ARCHERI Archer's Robin S10. 26 g.

This species was studied in Buganda and the eastern Congo where it is a characteristic species of dense thickets and tangled undergrowth in montane forest. It seemed often to be particularly associated with stands of tree ferns (*Cyathea* sp.). Chapin notes that six stomachs he examined all contained beetles, one some termites and one a millipede. Archer's Robin seems very strongly adapted to ground feeding, though fruit was found in one of the stomachs.

COSSYPHA ANOMALA Grey-breasted Robin S9. 26 g.

Placed by White in the genus *Alethe*, but as pointed out by Chapin (1953) this and the preceding species belong to the same group. They differ markedly in morphology as well as habits from both *Alethe* and *Cossypha*.

The Grey-breasted Robin was studied in Malawi; like *C. archeri* it is a montane evergreen forest bird, and the figures for the diets of the two species in Table 7 show a close approach to each other.

COSSYPHA POLIOPTERA Grey-winged Robin S6. 20 g.

This is an interesting little Cossypha, appearing to inhabit gallery forest over much of its range. In north-western Zambia where studied by the author, it inhabits the same types of forest as the similar sized and coloured *C. bocagei*, but the two never seem to occur together. It keeps much more to the undergrowth than does Bocage's Robin and was not noted leaving the cover of the gallery forests. There are no published details of its food other than 'insects' and it is said to be readily trapped with termite bait, but so is any robin so this is not very conclusive. In Zambia it was usually found hunting in swamp forest, and in particular over areas of boggy, inundated floor, where termites are unlikely to occur.

COSSYPHA NATALENSIS Natal or Red-capped Robin S33; F14. 33 g.

A robust and relatively pugnacious species, quite capable of supplanting a thrush three times its weight from a food source. The Natal Robin is mainly a species of lowland forest though it may also inhabit evergreen cover along streams in woodland zones. It is a species much addicted to seasonal movements, the full extent and significance of which are not yet understood. It is widely distributed, mainly over the eastern half of the continent.

C. natalensis is a regular attendant at ant columns and also utilises working mole-rats. It will be obvious from Table 7 that it exploits a wide prey spectrum with beetles and ants predominating. Like other robins it is prone to emerge from cover at dusk and it ascends readily into the lower canopy to obtain fruits. The great bulk of its food is obtained from the search of leaf litter on the ground.

COSSYPHA CAFFRA Cape Robin S17; F87. 28 g.

A species that is widespread in South Africa and becomes increasingly specialised with decrease in latitude, so that north of the Zambezi it is characteristically a bird of the bracken-briar fringe of montane evergreen forest. It indulges in much altitudinal migration and local movement, at least as far north as southern Malawi, and birds involved must undergo seasonal modification of diet. It very readily enters and resides in disturbed habitats in South Africa provided that there is enough cover. The sample analyses show that ants predominate in the diet, and that fruit is taken nearly as frequently as beetles. Termites are eaten avidly by those birds frequenting *Acacia* woods. Writing of the race *C. c. kivuensis* Chapin records that the food consists of 'small insects varied with fruits such as the mountain blackberries'. Unfortunately the samples contain none from birds of the Cape Province, only four from the Transvaal and three from Malawi. The remaining 98 are all from Natal and Zululand.

COSSYPHA CYANOCAMPTER Blue-shouldered Robin S2. 30 g.

This robin is a bird of the equatorial rain forest, being invariably found in dense secondary growth and thickets. Because of the very dense nature of the cover it frequents it is a very difficult species to observe. Two specimens collected in the eastern Congo had both eaten ants, adult lepidopterans and millipedes; one had also eaten several weevils and the other a 25 mm long caterpillar. Chapin examined 15 stomachs and found no trace of fruit, but insects were always present. These were mostly small beetles; five birds had eaten caterpillars (one hairy), one had eaten many termite workers, and one a green cicada.

COSSYPHA HEUGLINI Heuglin's Robin S19; F9. 38 g.

Heuglin's Robin is the most wide-ranging Cossypha on the continent, its distribution extending from the Sudan in the north to Zululand in the south. By preference it is a frequenter of large thickets and bush clumps, and because these so frequently result from habitat disturbance it readily adapts itself to well-populated areas. Like the Natal Robin it is a bold and often pugnacious bird and may readily attack any other species that intrude into its territory. In the southern parts of its range it is frequently found alongside the Natal Robin, and comparison of the relevant columns in Table 7 reveals many similarities in the prey choice of these two species. Most of the samples have been collected in Zululand, one in the Transvaal, two in Malawi and three each in Zambia and the eastern Congo. Chapin mentions that the stomach of a single specimen collected at Boma was filled with blackish termite alates.

COSSYPHA DICHROA Chorister Robin S11; F33. 44 g.

A South African endemic species, typically inhabiting temperate forest from sea-level at Knysna to over 1,800 metres in Natal and the Transvaal. There is regular movement to the lower levels during the winter months in Natal, but unlike some of the other

altitudinal migrants, *C. dichroa* will frequent only well-developed evergreen forest in its winter quarters.

The Chorister Robin spends more time in the upper levels of the forest than any of the other robins considered here, and during the summer months appears to be able to find most of its food in the canopy. In winter, however, and when feeding young, these robins descend regularly to forage on the forest floor. They eat considerable quantities of berries, more than most other robins. Although the 57% occurrence of fruit in samples is lower than the 65% of the Cape Robin, the proportion of fruit to insects is high in most samples.

19. NOTES ON THE FOOD OF *PHYLLASTREPHUS TERRESTRIS*

In Natal, where most of the data for the present study was collected, ground-feeding robins in evergreen forest and woodland habitats appear to share the food resources of the forest floor with several unrelated species as well as with each other. The most widespread and obvious of these unrelated birds is the Terrestrial Bulbul, *Phyllastrephus terrestris*. This Bulbul weighs some 39 grams on average, is a gregarious species with the average sized flock comprising some seven individuals, and does most of its foraging on the ground.

In order to learn something of the diet of this species, four stomachs and 11 faecal samples were collected from adult birds in various localities and habitats. The results of the analyses are given in the final column of Table 7. There are several differences in the percentage occurrence of food categories compared with the robins, but some of these require qualification. The figure of 87% for fruit is higher than any robin, as might be expected from a bulbul, but in many of the samples there is evidence to suggest that the fruit or seeds in question have been picked up off the ground, for there are often signs of germination. Beetles are paramount amongst the arthropod fare, and in two samples weevils were identified. Of the five samples in which lepidopteran remains were present, adults had been eaten in four and caterpillars in two. No wasps or bees and no millipedes are represented and the flies occurred in only one sample. The single record for other Insecta refers to an antlion larva, Myrmeleonidae (Neuroptera).

It is evident that there is a wide degree of overlap between the diet of this bulbul and the diets of those robins with which it shares the various habitats, notably *E. quadrivirgata*, *E. signata*, *P. stellata*, *C. humeralis*, *C. natalensis*, *C. caffra*, *C. heuglini* and *C. dichroa*.

20. SYSTEMATIC LIST OF INVERTEBRATE FOOD

In this section details are given where possible of the degree to which the taxa which go to make up the different prey categories are exploited. This is more successfully achieved in some categories than others, owing to the difficulties attendant upon identifying fragmented insects. Notes are also given of the proportion of adult to larval forms of insects in samples. The classification follows Brues, Melander & Carpenter (1954).

ORTHOPTERA Occurred in 93 samples

From the beginning of this survey the roaches were included with the orthopterans. As they are not taken all that regularly by robins there seems little point in creating a separate food category for them. They are included here along with the usual orthopteran families.

The representation within this group is as follows (numerals indicate sample numbers): *Blattaria*, 13; *Mantoidea*, 8; *Saltatoria*, 50; *Phasmatoidea*, 1.

Tettigonids and Acridids, especially forest-dwelling species, make up the bulk of these samples. The insects are usually well broken up by the birds before being swallowed, so few specimens have been sufficiently intact for more specific identification. A single stick insect (*Phasmatidae*) was eaten by *Cossypha archeri* in Buganda, and a pygmy mole cricket (*Tridactylidae*) by *Cossypha humeralis* in Zululand.

ISOPTERA Occurred in 147 samples

Three families are represented in the samples: *Hodotermitidae*, 6 (*Hodotermes mossambicus*); *Rhinotermitidae*, 2; *Termitidae*, 90. In the latter family, three subfamilies are represented, namely *Amitermitinae*, *Macrotermitinae* and *Nasutitermitinae*. The genera *Microcerotermes* and *Odontotermes* have been identified in 11 and 7 samples respectively on the basis of soldier remains.

Termites are eaten avidly by most robins if they encounter them; some species are particularly adept at finding them, particularly the scrub-robins. The workers are the caste usually eaten though some soldiers are often taken, probably inadvertently. Strangely, the alates, so often recorded as bird food, appear seldom to be eaten by robins on the basis of this survey, being found in only 2 out of 532 samples. One of these was from a Natal Robin, the stomach of which was crammed with termite alates and contained nothing else.

HEMIPTERA Occurred in 99 samples

Representation in the sub-order *Homoptera* was as follows: *Cicadidae*, 2; *Membracidae*, 1; *Fulgoridae*, 3; *Chermidae*, 2; *Aphidoidea*, 1; unidentified, 2.

The *Heteroptera* were more frequently eaten: *Pentatomidae*, 9; *Cydnidae*, 1; *Coreidae*, 1; *Lygaeidae*, 4; *Pyrrhocoridae*, 3; *Tingidae*, 1; *Reduviidae*, 5; *Miridae*, 1; *Anthocoridae*, 1; *Henicocephalidae*, 2; *Naucoridae*, 1; unidentified, 10.

The exploitation appears to be fairly widespread over the whole group, with no marked preference for single families.

LEPIDOPTERA Occurred in 219 samples

Easily detectable in samples, but these soft-bodied insects were usually too well crushed to be identifiable. Adult forms occurred in 149 samples and caterpillars in 95 (two of which were noted as being 'hairy').

Aside from the larvae, the bulk of lepidopteran remains seem to be derived from moths. Butterflies, quite apart from the distasteful properties of some, are probably too difficult for robins to catch. I have seen a Cape Robin dart into a road to snatch a butterfly just maimed by a passing car, and a butterfly egg was found in a sample from the same species. Parts of adult moths have been found in nine samples, and of the larvae, three were obviously *Geometridae* and two were *Sphingidae*.

DIPTERA Occurred in 62 samples

Adults were found in 58 samples and larval forms in 9 samples. The following families have been identified: *Nematocera*: *Tipulidae*, 6 (including *Styringomyia* sp.); *Chironomidae* 1; *Mycetophilidae*, 1; *Bibionidae*, 1 (*Plecia* sp.). *Brachycera*: *Tabanidae*, 3; *Asilidae*, 1; *Bombyliidae*, 1; *Muscidae*, 2; *Trypetidae*, 1; *Sepsidae*, 2; *Diopsidae*, 3; *Calliphoridae*, 1.

COLEOPTERA Occurred in 384 samples

Coleopteran larvae were found in only 20 samples. Family representation is as follows: *Carabidae*, 23; *Staphylinidae*, 6; *Cucujidae*, 1; *Lampyridae*, 1; *Anthicidae*, 1 (*Formicomus rubricollis*, eaten by *C. heuglini*); *Elateridae*, 12; *Buprestidae*, 14; *Coccinellidae*, 6; *Tenebrionidae*, 17 (including *Cyrtotyche* sp. eaten by *C. dichroa*); *Lagriidae*, 1; *Chrysomelidae*, 10; *Curculionoidea*, 82; *Scarabaeidae*, 49; *Melolonthidae*, 2. There is no doubt that the bulk of the attention falls on a few families, headed by the weevils.

FORMICOIDEA Occurred in 376 samples

Four ant subfamilies have been represented in samples as follows: *Ponerinae*, 20; *Dorylinae*, 39; *Camponotinae*, 13; *Myrmicinae*, 73. The figure for Doryline ants is definitely influenced by the role these ants play as beaters of other insects (see p. 299); in general their representation in samples is limited to a few individuals. Ants probably vary widely in their palatability to birds. Because of the relatively small size and robust nature of these insects, they are frequently found practically intact even in faecal samples, but identification is not made any easier by the polynomial nomenclature employed in the systematics of this group. The following genera have been identified: *Ponera*, 1; *Megaponera*, 1; *Anomma*, 3; *Dorylus*, 16; *Polyrachis*, 7; *Camponotus*, 2; *Pheidole*, 15; *Crematogaster*, 8; *Cataulacus*, 4; *Tetramorium*, 8; *Sima*, 1.

The tiny myrmicine ants are definitely the most favoured, as many as 500 sometimes being found in the stomach of one bird.

Other *HYMENOPTERA* Occurred in 67 samples

Wasps occurred in 51 samples, bees in 5.

Because of the very small size of many of the wasps eaten, they are usually impossible to identify or classify from the minute remains that are found in samples. The following families have been reliably named however: *Braconidae*, 2; *Ichneumonidae*, 7; *Chalcididae*, 2; *Cynipoidea*, 1.

Other *INSECTA* Occurred in 13 samples

It is surprising how seldom insects other than those in the groups mentioned above are eaten. The following orders have been recorded under this category:

PLECTOPTERA: 2 (eaten by *P. stellata* and *S. swynnertoni*).

DERMAPTERA: 2 (eaten by *P. stellata* and *C. heuglini*).

CORRODENTIA, Psocidae: 4 (*P. stellata*, 2; *C. natalensis*, 2).

NEUROPTERA, Mantispidae: 2 (*C. bocagei*; *C. natalensis*). *Myrmeleontidae*: 1 (eaten by *E. leucophrys*).

CRUSTACEA Occurred in 14 samples

The majority of samples in this category were small isopods. Two samples contained *Oniscoidea*, and a Natal Robin in the Congo appeared to have eaten a small crab.

ARANEIDA Occurred in 93 samples

Spiders are sufficiently popular prey items to warrant their own category. Being soft-bodied, they are easily broken up and identity is difficult. The following families have been found in the samples however: *Salticidae*, 6; *Oxyopidae*, 1; *Lycosidae*, 1; *Dysderidae*, 1; *Attidae*, 1; *Argyopidae*, 1. This last family was represented by *Gasteracantha* sp. and was found in the stomach of a Natal Robin. There is no proof that the bird took the spider from its web however; it could have found it on the ground or under a leaf. Orb-weaving spiders are seldom captured by birds.

Other *ARACHNIDA* Occurred in 24 samples

These are represented by: *Scorpionida*, 5; *Solpugida*, 2; *Chelonithida*, 2; *Acarina, Parasitoidea*, 7; *Ixodoidea*, 8.

Robins appear to take these arthropods only rarely.

MYRIAPODA Occurred in 58 samples

Diplopoda (millipedes) were found in 51 samples and *Chilopoda* (centipedes) in 11. Two of the latter belonged to the genus *Cormocephalus* and were eaten by *Cossypha dichroa*.

MOLLUSCA Occurred in 3 samples

Molluscs are not an important food source for robins. Those that are eaten are usually very small terrestrial species inhabiting the humus layer of the forest. A few of those in samples have proved to be predatory snails of the genus *Gulella*.

21. VERTEBRATE PREY

Tiny bones have been found amongst the stomach contents of three species of robin and seem most likely to have been derived from very small species of frogs. It is reasonable to suppose that robins would eat small frogs if they encountered them; the tame Heuglin's Robin mentioned in section 5 certainly did, and I have seen the Olive Thrush, *Turdus olivaceous*, subdue a burrowing frog, *Breviceps adspersus*, which it had found under leaf litter.

22. DISCUSSION

This study of the food and feeding habits of African robins is really no more than a preliminary survey of the subject, given in detail in order to facilitate comparison with other groups or species of African birds. It does not purport to solve the contentious problem of the role of food as a limiting factor in the tropical environment, though it contains much that can be used in a discussion of this subject.

It is interesting to compare the overall picture presented here with that pertaining to the well-studied and closely related European Robin, *Erithacus rubecula*, as set out in Lack's classic work, *The Life of the Robin* (1946). The chapter 'Food, Feeding and Being Fed Upon', summarises the robin's diet and feeding habits, and the reader will find innumerable parallels with what has been written here. The English Robin 'takes almost any insect it can get' and it 'also eats spiders, centipedes, earthworms, and small land molluscs, while vegetable food includes small seeds and many small fruits . . .'. But in England, in winter, insects 'are not so easily found', with the result that robins indulge in migrations to the

warmer south or local movements from woods to human dwellings. It has been mentioned in this paper that many robins indulge in altitudinal migration or local movements, but the circumstances and details are more complex, and there are several reasons for suggesting that food shortage is not, for African robins, a serious ecological factor (Oatley, 1966).

However, a great deal still remains to be learnt, and very large numbers of samples will be required if a clear insight is to be gained into fundamental issues. For example, it is evident from the data presented here that the diets of these closely related birds overlap, but much finer detail will be required to determine whether the overlap is significant.

It is an unfortunate fact that thousands of birds are shot in Africa every year for no other purpose than to provide material for systematists, who load an already overburdened literature with further discussions of the validity of avian subspecies. If the stomachs of only a fraction of these birds were to be preserved, great strides could be made in our understanding of one of the most basic aspects of African bird ecology.

23. ACKNOWLEDGEMENTS

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24. SUMMARY

Data on the food and feeding habits of 22 species of African robins (Aves, Turdinae) have been collected during the last 15 years. The details of diet are derived largely from the analysis of over 500 stomachs and faecal samples, and the importance of the different food classes is expressed as a percentage of the total sample numbers in which representation occurred.

The majority of robins obtain their food on or near the ground, although several forest-dwelling species also feed in the canopy to a greater or lesser extent. Robins are usually solitary birds and are not in the habit of joining mixed bird parties which commonly occur in woodland and forest areas; they do, however, associate with various mammal beaters, and are greatly attracted by Doryline driver ant columns.

Robins feed most intensively in the early morning, again at around noon and finally just before dusk. Feeding intensity is relatively low during most of the afternoon. Light intensity seems to be an important regulating factor in feeding behaviour.

The feeding habits of a hand-reared *Cossypha heuglini* are detailed. This bird ate mostly very small insects, but would take large insects up to 60 mm long when these were made available. This bird seldom pursued flying insects, but had a great ability to detect well-camouflaged, motionless insects. Taste appeared to play an important part in its acceptance of food.

Robins usually take invertebrate prey of small size. The mean length of 243 measurable arthropods (excluding ants and termites) was found to be 14·4 mm. The prey spectrum is wide, up to 16 different species of invertebrates having been found in the stomach of one bird.

Fruit is eaten by many species of robins but appears to be taken from choice rather than necessity. Nectar feeding is rarely practised. Fine grit is often found in stomachs but is ingested accidentally and is voided with the faeces.

The amount of drinking done by robins varies considerably from species to species. The semi-desert species seem least dependent on water, but at least one forest species appears to need it regularly.

Different individuals of the same species may have rather different diets, even when feeding in the same area. Seasonal variation in diet may be brought about by many factors, chief among which are altitudinal movements by the birds themselves which tend to take them into different habitats.

Some examples are given of the foods eaten by robins in five different vegetation zones and interesting differences between the available food supplies are revealed.

Foods given to nestling or fledgeling robins have been little studied but appear to be much like those of the parents with a possibly higher proportion of larvae and soft-bodied forms. Immature robins have to learn about insect palatability as they are the ones most frequently found with normally distasteful prey in their stomachs. Robins readily take a range of processed foods when feeding in the vicinity of human dwellings.

Individual notes are given on each of the 22 species of robins used in the survey and some notes are given on the food and feeding habits of a potentially competitive species of bulbul, *Phyllastrephus terrestris*.

The invertebrate food is listed in systematic order and the degree to which different families are exploited is shown in terms of material identified in samples.

It is noted that there are similarities between the food and feeding behaviour of African robins and the closely related European Robin, *Erithacus rubecula*. It is considered that food shortage is not a serious ecological factor for the species considered in this survey, but considerably more data must be collected before any firm conclusions can be drawn.

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